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Mind-Set and Learning¹

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"I wish I understood these 'laws of learning.' Everywhere I go some one refers to them. They sound very imposing—and mysterious—but do they really amount to anything? How did the world manage to get on so long without them?"

"Well, you may be interested in the laws of learning, but I'm not. I don't see the use of teachers worrying their heads about psychology. Teaching has to do with children, real live children; but psychology is as dead as other things that live only in books. Teaching is hard enough and dry enough without having to learn psychology besides. If I went to summer school, which I don't intend to do, I'd study photography or something else interesting, but you'd never catch me in educational psychology. Besides, when I go off in the summer I don't want to be always reminded of my work. September to June is enough for me."

"Yes, we all know how you feel on such matters; but I believe one reason why you find teaching dry and hard is exactly because you don't study it. At summer school last year I found out so many new things about children and how they learn, and heard so much of the plans and experiments of the other students, that I could hardly wait for school to begin again. I was so eager to see those things in my pupils and to try some experiments of my own. You will perhaps say I have always liked teaching. So I have in a way, but teaching the same way year in and year out was getting to be pretty monotonous. Now it's a different thing. I have more interesting things to watch than you can imagine. But I must admit that I don't seem to see all my psychology as clearly now

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as when we were discussing it in the class. More difficulties have arisen than I ever dreamed of. For one thing the psychology seems more complicated, not only when I watch for it in my pupils but also when I try to straighten it all out in my mind. There's nothing I'd like better than for us to talk it over, but I warn you I'll raise many questions. For I want to know."

"If psychology or anything else will keep teaching my brats from being humdrum, I'll say, "Yes, let's study it." I am willing to listen awhile and see how your discussion starts off, but I tell you beforehand I'm skeptical of it all. You don't know my pupils. Psychology may help your nice well-dressed children who come from good homes, but it takes something stronger for mine. My first step with each new class is to put the fear of God in their souls. After that I can sometimes do something with them. Perhaps I might even use psychology then, if I knew enough about it."

"Where shall we begin? Some one suggested the laws of learning."

"That's my first question: why do you say 'law'? I know you don't mean that we have to obey Thorndike or whoever first made those laws, so why say law?"

"A law of learning is like any law of nature. Newton didn't *make* the law of gravitation; he *discovered* it. As I understand it, a law of nature is nothing but a statement of an observed regularity. Galileo discovered certain laws of falling bodies, but bodies fell afterwards just exactly as they had fallen before. They didn't pay any attention to Galileo. He only told what they do, regularly do, always do, so far as he could tell. The laws were merely exact statements of how bodies fall."

"Well, if that's all I don't see the use of laws. Why bother with them?"

"The use is this: if we know what to expect of falling bodies, we then know how to act where falling bodies are concerned."

"That's nothing but common sense, isn't it? Where does the science come in?"

"Science is itself nothing but common sense, common sense more careful of itself. Science is based on experience just as common sense, but it has more exact ways of measuring and

of telling. In particular it tries to include many experiences under one statement. A law of nature is merely a very inclusive, very careful, and very reliable statement of what to expect."

"That sounds reasonable, but apply it to our topic. What is a law of learning?"

"A law of learning would be nothing but a very carefully made and very inclusive statement of how learning takes place."

"Give us one of your laws of learning. I'd like to know how learning takes place. Perhaps I'd know better how to make my pupils learn."

"I'll give you the Law of Readiness: When a bond is ready to act, to act gives satisfaction and not to act—"

"Now there you go with your outlandish jargon. Why don't you use everyday English. Bond! What is a bond?"

"That is the trouble about trying to be exact. As a matter of fact I fear I have over-simplified it now. I think, though, we'll have to begin further back. We'll have to get some preliminary terms or give up the effort to use understandingly the laws of learning."

"Go on. Only don't give us too many."

"Let's begin with S — R and build up from there. S stands for stimulus, or perhaps, more exactly, for situation acting as stimulus; and R stands for response. Any act of conduct is a response (R) to some sort of situation (S). I hear a child crying (S), I stop and listen (R). I meet a friend on the street (S), I say 'good morning' (R). My friend sees me and hears me speak (S), he responds in like fashion (R). He notices that I stop walking (S), he stops (R). I see that he is within hearing distance and attentive (S), I speak commanding his address of last evening (R). He hears me speak (S), the meanings of my words arise in his mind (R). He appropriates my meaning (S), his face flushes and he feels gratification (R)."

"You haven't said a word about bond or connection. Please explain that. I told you I'd raise many questions."

"Notice the next to the last instance given: He hears me speak (S), the meanings of my words arise in his mind (R). If he had not in the past learned the meanings of these words, my voice would have stuck in vain upon his ears. The meanings

could arise in his mind only because in the past he had learned to associate thenceforth these meanings with these sounds. That is, his past experience had built up somewhere in him—in his nervous system, in fact—such connections or bonds that when a particular sound is heard (e. g., my spoken words *magnificent address*), its appropriate meaning arises as a thought in his mind. Each such language connection or bond has to be learned, that is, built up by and in experience."

"But not all bonds are built up or learned, are they?"

"No, that is what I was about to say. My friend flushed with pleasure (R), when I commended his address (S). His being pleased at commendation and his flushing in connection were not learned; these responses are innately joined. Each one of us is born with many such responses already joined by strong bonds to their appropriate situations."

"What is the — in S — R? Is that the bond connecting S and R?"

"Yes. It is usually better to think of the situation (S) as being sized up or received by one nerve structure (or mechanism), the response (R) as made by a second, and the — as a third nerve structure that carries the stimulation from the structure (or mechanism) S to the structure (or mechanism) R. There are some difficulties in so simple a statement, but we shall not go far wrong so to take it."

"Do you mean that this S — R holds of everything we do? Everything?"

"That is exactly what I mean. All conduct of whatever kind is so described. Of course some situations are very simple, while others are very complex. And similarly with responses, some are simple, others exceedingly complex. The bonds also vary. Some are so simple, definite and 'strong' that as soon as the stimulus comes the response follows with almost mechanical promptness and certainty. You know how it is if one is struck sharply just above the knee cap, the knee flexes in spite of anything we can do to prevent it. Other connections or bonds are so weak, so little formed, that the least little interference will prevent the response. If I ask a third grade pupil what is 2×2 , he will say 4 at once. If I ask 7×6 , he may tell me 42, but he is likely not to feel very sure of it. If I ask 8×13 , he is almost sure not to know. Now it isn't a question of knowing 42 as a number in and of

itself, it is precisely a question of having or not having built a bond that joins 42 to 7×6 , so that: thought of 7×6 (S) is followed by 42(R). The arithmetic connections or bonds have to be built in order to be available for use. I wonder if the word 'learn' doesn't begin to take on a more definite meaning?"

"I see that S — R does join up with arithmetic and language; but does it fit all learning—geography, for example, or composition?"

"Most certainly. If one should ask about the capital of North Dakota, some will answer at once; others will hesitate, making perhaps several guesses; some won't know at all. The presence or absence of the bond and its strength if present tells the tale. So with composition work. One child will leave a straight margin to the left of the page, another will write as if there were no such thing. The difference is the presence or absence of the appropriate bond. One child will join with *and's* many short sentences. Another will consciously avoid it. So with morals. One boy in a tight place (S) will lie out of it (R). Another in the same tight place (S) will tell the exact truth unflinchingly (R). Everywhere it is a question of what bonds have or have not been built."

"Now tell us about readiness and satisfaction and annoyance. I have them fairly clear, but there are still some difficulties."

"And others of us know nothing about them as yet."

"Readiness is easier to see than to tell. I like to think of it as connected with the degree of stimulation needed at any given time to bring about a given response, the greater the readiness, the less stimulation is needed. Suppose a small boy and a heartless experimenter. One hot day the boy begs for ice cream, boasting recklessly that he can eat six helpings. The experimenter dares him to do it, saying that he will furnish the ice cream. The contest is on. Situation: a plate of ice cream before a small boy on a hot day. Response: the boy falls with alacrity upon the cream. Readiness is high. The second helping finds, if possible, even greater readiness. But toward the end of the third plate readiness sharply declines. The fourth sees readiness reduced to the zero point and even below. Readiness then is a condition of the neurone measuring the degree of its craving for activity."

"That is clear so far, but are there not other causes of readiness or unreadiness?"

"Indeed yes. Fatigue, due to extended exercise, is a common cause of unreadiness. (The case above was different. It was not so much exercise of jaw or palate nerves as it was fullness of stomach that reduced below zero the readiness for ice cream.) Preoccupation with something else of an opposing kind may also bring unreadiness, as when fear or sorrow cause unreadiness for mirth. A most important source of readiness is *set*, one's mental attitude at the time."

"I wish you would tell us about set. I have heard so much about set and purpose that I just must straighten them out. What is the connection between set and purpose? But first, what is the difference between set and readiness? They seem much alike to me."

"They are much alike and sometimes confused, but I believe we can make a clear distinction between the two. Set is broader than readiness. Readiness is best thought of as belonging to one response bond (possibly a compound response bond), while set refers to the mind acting more or less as a whole (or for our purposes, set more precisely belongs to an aggregate of bonds that for the time being have practical charge of the person or organism).¹ The term mind-set-to-an-end brings out perhaps more clearly what I have in mind. The emphasis here is on one controlling end which seems to possess the mind. The organism is bent or set upon attaining this end (typically an external end). The practical relations between set and readiness are here most interesting. A boy gifted in baseball is anxious that his team shall win in the match next Saturday. We may say that he is 'set' on winning the match. This set reaches out to many allied and auxiliary response bonds and makes them *ready* for the part they may possibly play in attaining the end in view. The boy's ear will be 'wide open' to hear any useful 'dope' on the game. His eye will be 'peeled' to see the curves of the opposing pitcher. This effect is general, the mind-set-to-an-end in fact makes more ready all one's inner resources (response bonds) that by previous inner connection seem pertinent to the activity at hand. Nor is this all. Simultaneously with passing on readi-

¹ There is still a slightly different sense in which the mind set makes one see everything as "roseate" or makes one "blue."

ness to pertinent bonds, this set also makes unready all those response bonds whose action might interfere with attaining the end in view. The same thing that made our baseball boy ready for the necessary practice during the preceding week made him correspondingly unready for anything that might interfere with that practice. Every teacher knows that little study is given to books just in advance of any engrossing contest. Some college teachers say no serious study is possible till after the Thanksgiving games."

"You have struck something live now. But you seem almost to make a thinking being out of mind-set. It entertains ends. It seems to know what will help and what will hinder action to these ends. I don't see what becomes of the person—his self, I mean."

"Your inquiry raises a real difficulty, but it is a difficulty rather of language than of fact, I believe. Suppose a little girl walking by a toy shop. Her shoes have been hurting her feet. All at once her eyes fall on a fairy vision of a doll. Her heart (aggregate of S — R bonds capable of forming a mind-set) responds at once. She wants the doll. A set for possessing the doll is in possession of the girl. Shoes are forgot, bystanders vanish. She and the doll for one brief moment make up the whole world, but in another moment the mother is included: 'O Mother! I want her so much. Please get her for me.' Then that world enlarges to include in succession shopkeeper, price, money, possible sources of money, Father, Uncle George. A formal analysis will perhaps make clear the life history and action of this psychological set: (i) there must be available for stimulation certain end-setting-up S — R bonds (here the doll-appropriating response and, likely enough, bonds for doll-carriages, ice cream, etc.); (ii) something (here the chance sight of the doll) stimulates one such available S — R bond; (iii) a response follows, wherein an end is set up (here the strong wish for the doll); (iv) from this 'set' the spread of 'readiness' through previously made connections to allied and auxiliary S — R bonds (here become 'ready' the bonds for asking Father or Uncle George); (v) a similar and simultaneous spread of unreadiness to such other S — R response bonds as might thwart or unnecessarily postpone the doll-appropriating activities (the pains from the shoes are forgot); (vi) then follows the auxiliary action of

the most ready of the allied S — R bonds ('O Mother, please get her for me'). Thus instead of using the mysteries of self and thinking to explain what has here gone on, we must, I think, ultimately explain from the inside and along these lines what a self is and how thinking proceeds. But that's another story."

"Well, we have to admit that psychology is not as dead or dry as I said. But how are you going to use all this? What bearing has it on your laws of learning that you began to talk about?"

"Possibly when we take them up our digression will be justified. Suppose we begin now? Thorndike gives three major laws, those of Readiness, of Use and Disuse (or Exercise), and of Satisfaction and Annoyance (or Effect). The Law of Readiness follows well what we have been discussing: *When a bond is ready to act, to act gives satisfaction and not to act gives annoyance.* *When a bond is not ready to act, to be forced to act gives annoyance.* Think what we have been saying about readiness, and see if this law does not sound reasonable."

"Why, yes indeed. That boy and the ice cream—as long as the ice-cream-eating bonds were ready to act, he got satisfaction from his eating. And the less ready he became, the less satisfaction he got from his eating. I suppose if he had been compelled to eat all six plates, it would have proved very annoying. Yes, this law is clear, but I have been wondering if it isn't a kind of definition of what is meant by satisfaction and annoyance. What do you say?"

"The question is a very interesting one. I am inclined to agree with you. But probably we had better not go into that discussion just now. Fix attention on readiness as a state of the neurone (or nerve structure) which disposes it to action, then this law throws its light on the meaning of satisfaction and annoyance. Probably our general experience has something else to add in any particular case. I am inclined to say that this law partly defines and partly joins things of which we have otherwise independent knowledge. Let us now go to the Law of Satisfaction and Annoyance."

"You skipped the Law of Use and Disuse. Do you wish to keep the order you first gave?"

"So we did skip it, and I believe it is best to take the other first. Before taking it up, consider what we are about. Some S — R bonds we bring into the world with us; others and the great majority we acquire after we get here. Of the innate bonds some fit our civilization and need to be maintained; others don't fit so well, and need to be changed or killed off. Acquiring new bonds or changing old ones is what we mean by learning. Perhaps our commonest work is strengthening or weakening bonds."

"What do you mean by strengthening a bond? When is a bond strong and when weak?"

"We strengthen a bond when we change the connection between any S and its R so that the response (R) will more likely follow the stimulation (S) or will follow more promptly or more definitely. Weakening is merely doing the contrary; though often people speak of weakening a bond when they really mean strengthening a substitute bond. Of course, pedagogically, this is usually the best way of weakening an undesirable bond."

"Can all bonds be changed? Or are there some beyond our influence?"

"There are some bonds practically beyond the power of education to modify. These we call reflexes. They belong especially to certain more mechanical actions of the body. Education too has limits fixed for it by nature. Of course then when we are speaking of learning we restrict ourselves to modifiable bonds."

"We are ready now to state the Law of Satisfaction and Annoyance (or Law of Effect): *A modifiable bond is strengthened or weakened according as satisfaction or annoyance attends its exercises.*"

"When we had this last summer our instructor led us to repeat many times: 'Satisfaction strengthens, annoyance weakens.' And then he would have us repeat the whole law. So that in the end we fixed it strongly in mind. It is a great law, all right. I never dreamed when I first heard it how much help it can give the teacher. But the more I watch my children learning, the more I believe that this law is the very bottom on which our learning rests and upon which we must base our school procedure."

"Let's go on and see how this law tells us what to expect in our teaching."

"I believe I see already how it all is going to work out. Mind-set-to-an-end is purpose. If the child has a strong purpose, this as mind-set pushes him on to attain his end. This mind-set makes ready his inner resources for attaining the end. When he succeeds, these ready neurones and the success both mean satisfaction; and satisfaction means strengthening the bonds used. He learns by doing. His purpose helps him learn. It must be so. Mind-set, readiness, success, satisfaction, learning—they follow just this way. Am I not right?"

The Project and the Project Method in General Science¹

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THE MASTER OF PROJECT METHOD.

In Dole, France, on Friday, December 27, 1822 at 2.00 o'clock in the morning, Louis Pasteur was born. The event was unheralded and quite unknown outside of the usual circle of family relatives and acquaintances of the neighborhood. At Vileneuve l'Etang on Saturday, September 28, 1895 at 4.40 in the afternoon occurred the death of Louis Pasteur. The death of the "First Man of France" was lamented not only by the great civic and scientific circles but by the lonely shepherd on the steeps bordering the foothills of the Urals and the rough caravan trader of the Orient, in short, from the far corners of the earth came expressions of regret mingled with gratitude in memory of a common benefactor. Indeed his name had already become a noun or a verb or both in nearly every written language. This man had become world famous, world honored and world beloved solely by his own achievements. No army or navy, no inherited kingship or emperorship, no political industrial or religious revolution brought about his rise to the pinnacle of world recognition,—simply the inheritance of an intellect which he willed and purposed to the service of humanity.

Rene Vallery-Radot, his son-in-law, records that "he was full of projects, and what he called the 'spirit of invention'

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daily suggested some new undertaking." The nature of these "undertakings" are suggested in the following statements:

1. To establish the truth or falsity of the so called "spontaneous generation."
2. To discover causes and effect remedies for the "diseases" in vinegar and wines.
3. To discover causes and effect remedies for "charbon" or splenic fever.
4. To set forth to the world the "germ theory of disease."
5. To establish by public experiment at Pouilly le Fort the success of vaccination as a preventive for splenic fever.
6. To make a study of the hydrophobia problem and to work out a preventive treatment of rabies.

The above projects in the order stated, associated with innumerable others, presented themselves to the mind of Louis Pasteur in the short space of twenty years. Pasteur's attack and successful conclusion of the above "undertakings" so related to the surety and happiness of life is well known and needs no recounting here, but a resume of Pasteur's method of conducting a research is worthy of serious attention, for by so doing we provide an opportunity for examining the "workings of a project method" in the hands of a master workman.

THE STATUS OF THE HYDROPHOBIA PROBLEM PREVIOUS TO PASTEUR'S ATTACK.

The most interesting of Pasteur's projects in preventive and curative medicine is concerned with his investigation of the dread disease of hydrophobia in man and rabies in animals. Prior to Pasteur's successful combat, hydrophobia remained the most mysterious and most fell disease to which man is subject. Homer has a warrior call Hector a mad dog. Aristotle speaks of the transmissions from one animal to another through bites and says that man is not subject to it. Some three centuries later Celsus records "the patient is tortured at the same time by thirst and by an invincible repulsion towards water." The historical methods of treating this disease were stupid, torturous or criminal. The use of corrosives and various caustics and the cauterizing of bites with a red hot iron were advised. As a cure Pliny the Elder recommended the livers of mad dogs. Galen opposed Pliny's recipe with a compound of cray-fish eyes. During the reign of Louis XIV sea bathing heretofore

unknown in France, became a fashionable cure of hydrophobia. These and many other quack remedies were the vogue. The long period of incubation required for the development of this disease only added misery and desolation to the unfortunate victims of the bites of rabid animals. They were outcasts to whom quarter and comfort were seldom, if ever, given. In many sections it became the custom to shoot, poison, strangle, suffocate or drown persons merely suspected of hydrophobia. As late as 1819 the Paris newspapers related the death by strangling and smothering between mattresses an unfortunate person suspected of hydrophobia. In 1831 Pasteur, a child of nine years, witnessed the terror spread by a rabid wolf and had seen the wounds of a victim cauterized with a red hot iron at the smithy. The cauterized victim lived, but several others after horrible suffering succumbed to the dread disease. Amidst the various researches undertaken by Pasteur one study was placed by him above every other, the one mystery of his mind,—the mystery of hydrophobia. Yet Pasteur was near his sixtieth year of life before he found himself prepared and ready to attack this most fateful of all diseases.

PASTEUR'S ATTACK AND SOLUTION OF THE HYDROPHOBIA PROBLEM

In the foregoing we set forth the conditions in which Pasteur found a research problem. Now let us examine and observe the methods of attack, of procedure, of organization and of definition that Pasteur employed in order to bring about the solution of the problem in hand. Let us observe the advancement made in each step taken, and how the results obtained at each and every step pointed out to his keen and plastic mind the next required step and thus to the successful termination of the undertaking. The major steps in the solution of the hydrophobia problem were as follows:

1. To begin Pasteur made a study of rabid dogs. Countless laboratory experiments were carried on while making this study of rabid dogs. This first step led him to conclude that the virus had its seat in the nerve centers.
2. A closer study directed at the nerve centers led him to inject a portion of the matter of the spinal column of a rabid dog into the body of a healthy dog. Results of such injections invariably produced the symptoms of rabies.

3. The next step was to endeavor so to modify and weaken the virus as to enable it to be used as a preventive or as an antitoxin. This proved to be a vexing undertaking, but after long and serious labor he obtained the much desired result, namely an inoculated dog to be immune when bitten by a rabid animal.
4. But this was not enough. Would the inoculation of the attenuated virus have a remedial effect on an animal already bitten? A number of dogs were inoculated, the same number were untreated, and both sets bitten by rabid animals. All treated dogs lived; all the untreated died from rabies.
5. It was, however, one thing to experiment on dogs, and quite another to do so on human beings. Nevertheless Pasteur was bold enough to try. The trial was successful, and by so doing he earned the gratitude of the human race.

This simple portrayal of Pasteur's activities may be misleading to some of us. We may think that the passing from step to step was a very simple matter, and that Pasteur saw from the beginning a well defined method of procedure, that was certain of the desired results. Such was not the case. Each step taken was beset with difficulties and obstacles that required a sacrifice of mind and body that few men care to make. Literally hundreds of experimental trials and retrials were made at every step in order to gain an insight that would point out the next successful step. This recital of Pasteur's attack, his conquest, and triumphant victory over this disease lays before us the "workings of the project method" in the hands of a master.

CHARACTERISTIC OF THE PROJECT METHOD

Time and space prevent the consideration of the other masters in other fields of activity, suffice to say, however, that Galileo, Lavoisier, Davy, Faraday, Kelvin, Ramsay and others exemplified throughout their lives and undertakings the principles of the project method. The method employed by the masters is simply a natural method of procedure that may be analyzed into the following characteristic stages that are more or less interrelated than well defined:

1. A doubtful or perplexed state of mind regarding a given question, problem or situation.
2. A conviction that the problem or situation is worthy and reasonably possible of solution.

3. A quest in search of information and experience pertinent to the problem or question in hand.
4. An establishment of theories, guesses, or hypotheses that serves as a means to the end.
5. An arrangement or a formulation of facts and evidence that follows through to successful conclusion,—a conclusion that dispels the perplexity of mind—a conclusion that may or may not be final.

The identities of the project method as set forth above are not only characteristic of the activities of Edison or Michelson or Madame Curie, but of children before entering school and of children and teachers out of school. In short the project method is a natural procedure undertaken by a self willed individual or individuals in quest of pertinent information that will dispel to a more or less degree a perplexity of mind.

PROJECT METHOD DEPENDS UPON THE PURPOSE OF THE COURSE

Now is it possible to adapt the method of the scientist to children pursuing a course in general science? The answer to this question is determined solely by the purpose we assign to such a course. If we as teachers use the course as an opportunity to impart our knowledge of the subject matter or to merely interpret some one else's knowledge of the subject matter as set down in a text, we shall have succeeded as haranguers and interpreters to an audience who listens well to day and forgets much tomorrow. On the other hand if the purpose of the course is to provide and occasion means by which the children are stimulated to seek information in the achievement of ends sought, then the method of the scientist,—essentially the project method,—is adaptable.

THE NECESSITY OF A SCIENTIFIC ATTITUDE.

Teachers who are in the habit of assigning so much codified subject matter accompanied by a set of formal experiments, lecture or laboratory, fail to develop the scientific attitude in their pupils. A course in any science that makes no provision for initiative on the part of the pupil, no provision for the selection of facts according to their value, no provision for trial, no provision for creative thinking can never boast of imparting to the least degree the spirit of scientific attitude. Without a development of a scientific attitude how can there be growth of power in the judgment and appreciation of values? Without

the scientific attitude how can there be any desire for nice discriminations,—accurate selection or rigid elimination?

THE PROJECT.

Thus far much has been said about the project method and little about the project. This condition of affairs is deliberate. For the writer contends that if one is familiar with the project method, the concept of what a project is and what a project is not is quite obvious. So long as Pasteur viewed from a distance the hydrophobia problem it remained a problem. But the moment that he challenged the problem, the moment that he began to investigate it in its own field of action, the moment that he began to define it or establish an hypothesis concerning it and to draw conclusions which would verify and thus directed his labors to bring the undertaking to a successful conclusion, that moment the problem became Pasteur's project,—Kilpatrick would say "the purposeful act" of Pasteur. In the pursuit of this project Pasteur consumed a great deal of time and energy, indeed at one stage of its development Pasteur found himself physically wrecked and invalided, yet he prevailed and succeeded to drive the undertaking to a successful conclusion. This element of success has become identified as a fundamental of the project. Again Pasteur pursued his project in surroundings that were wholly fitting to the question in hand, that is the setting was natural. In summary then a project is a "purposeful act" pursued in a natural setting to a successful conclusion.

FORMAL METHODS VERSUS THE PROJECT METHOD.

From the foregoing considerations we readily see that there is nothing new in the project or project method. Indeed it has been used to a greater or less extent throughout the schools of the land by teachers who sought to inject into their several courses an actuality and a worthiness of enterprise that could not thus be obtained from the old and time honored methods known as topic, problem and question. The teacher of general science may assign topics on ventilation from the text in hand, from references, or, in fact, may develop the principles from drawings on the board or chart and require the pupils to acquire a mastery of details and principles thus assigned and

presented. This method of procedure is convenient, and it is, indeed, quite the habit. It is not problematical to say that the majority of the children have had no previous interest in the topic or subject thus assigned,—no "set of feeling" of decided worthiness established in behalf of the question in hand. However the discipline of the school demands preparation, and preparation of it is of an artificial sort.

On the other hand the teacher may do the more natural thing which is that of having the pupils and himself observe and make a study of the ventilation of the room in which they find themselves situated, and from thence to that of the building in which the room is located. This sort of procedure arouses an interest that aids to establish a "set of feelings" for the thing in question. Such a "set of feelings" usually urges the possessor to seek further satisfaction by continuing the investigation of the affair. Such pupils will of their own accord investigate the home heating plant and modifications of the same as found in various other types of buildings. In fact if the teacher is in the habit of approaching the situations and problems of the course by examining the situation or problem as it exists in the child's environment,—home and community,—the child soon forms the habit of "carrying on." A multitude of minor and personal problems will occur to him. Some of these problems will be found worthy of acceptance, investigation, definition, indeed they will have become "purposeful activities." As such a course proceeds the spirit of inquiry develops as a logical sequence.

The results obtained from this latter method of procedure are denied and contested by those teachers who have always made use of the more formal and time worn method of demanding a knowledge of fact and principle in priority of a study of the situation or problem in its natural setting. The course that demands priority of fact and principle seldom, if ever, develops a scientific attitude. Indeed, why should it? The child who finds himself in such a course has no need or use of a spirit of inquiry, for fact and principle *are learned* from the first, and hence the fact or principle becomes for the child a sort of a fairy wand which, when applied with proper rite and due ceremony, dispels or transforms the problematic situation that arises later. Such a child has had his intellectual appetite satisfied with no accompanying mental digestion.

A BACKGROUND THAT FOSTERS A SPIRIT OF INQUIRY IS NECESSARY.

Teachers who have never used the project method in the sciences should not attempt the method on a twenty-four-hour decision. The project method requires preparation, tact and patience. At first the results are discouraging. The pupils have been and are pursuing courses in other branches that are largely formal, and the pupils are so accustomed, and hence their conduct in which a project method is used for the first time is not one from habit. Right habits and attitudes will develop in direct proportion to the development of a spirit of honest inquiry into the how and the why of things. At first the background of the course should give rise to simple problems in which the pupil sees a possibility of solution and a worthiness of pursuit. The following exemplifies the point in question and is a verbatim copy of a reported activity of one of the girls of the eighth grade general science course in the University-School at Cincinnati. The problem arose out of a background that had to do with clothing materials.

M.....F.....
Grade 8

University-School
General Science.

HEAT CONDUCTING PROPERTIES BY WOOLEN AND COTTON MATERIALS.

The question was put before the class "Which is the better material for winter wear,—wool or cotton?" Deciding to find out I took two similar tin cans, a piece of serge and piece of gingham, two corks and two thermometers.

I took the cans, put a hole in the top and also a hole thru the corks by means of a file. I then put on the lid of each can and put two layers of serge around one can and two layers of gingham around the other, also over the tops and bottoms, leaving a space in the top of each directly above the holes so that I could put in the cork and the thermometer. Then I took a funnel placed it in the hole and poured the same amount of water in each.

I then pushed a thermometer through each cork and put a cork in each hole. The readings were:

Date Oct. 22, 1921	Time	Cotton	Wool
	3:47	83°C	82.5°C
	4:32	61	63
	5:10	52.5	57
	6:07	44	50.5
	7:05	37	45
	8:17	31.5	41
	9:26	27	39.5

In 5 hours and 39 minutes the can with the cotton material dropped 56°C. and the can with the wool dropped 43°C. Altogether the can with cotton dropped 13°C. more than the can with wool.

Conclusion: Cotton is a much better conductor than wool. This also explains the reason why we wear clothes of cotton materials in summer rather than woolen ones. It also answers a question I saw the other day about firemen wearing woolen shirts in summer time. The fires that they tend are hotter than their bodies. The woolen shirts are poor conductors and keep the heat away from their bodies.

While the above exposition of affairs is somewhat awkward, it sets forth an order of events that is unmistakable and worthy of merit. A mastery of simple perplexities lays a basis for the attack and mastery of the more complex. If a pupil fails to master a task set forth by another the failure is often excusable, but when a pupil undertakes a self set task and fails, his self confidence is weakened, especially so, if the background from which the problem sprung held forth glittering possibilities that were from the first untenable. A course in projects does not mean the complete elimination of the topic, question and problem methods of instruction, these latter methods are enriched and made more possible when preceded or accompanied by related projects. In setting forth a course in general science by means of projects the teacher is the skilled tactician, the silent general who guides and directs the uninitiated from the mastery of simple mysteries of life and nature to those more complex. Serfs and slaves had their tasks assigned, and moreover task masters set over them to drive them to the conclusion of the task,—not *their* task. When "knighthood was in flower" this condition of affairs was acceptable. But in a democracy the demands for practical efficiency and of moral responsibility make imperative the *self purposing* individual.

A Survey of the Status of General Science in California

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INTRODUCTION

One of the subjects on the high school curriculum which today is receiving a great deal of attention is general science. Educators feel that the course is not proving adequate as a first year science course.

General science was added to the curriculum because of the demand for a course which would give to the masses of the students, who do not reach the last two years of high school, an insight into the great field of science. As never before in the history of the world it is necessary that all men have something of a scientific knowledge but above all else a scientific interest and aptitude.

In making a survey of the general science situation in Illinois, Mr. C. F. Miller received the following criticisms of the course as it is now taught¹:-

1. "A piecemeal mixture of science, still kept distinct.
2. Course unbalanced, lacks unity of organization.
3. Emphasis placed by teachers or authors on special lines of enthusiasm.
4. Too difficult—not adapted to the age of the pupil.
5. Laboratory equipment not standardized.
6. Lacks consciousness of a general aim.
7. Lacks properly prepared teachers.
8. Teachers do not have the general science attitude.
9. General science teachers should be the most resourceful teachers in the faculty, and this type is difficult to find.
10. It is not accredited."

With such criticisms as these in mind a survey of the status of general science in California was made under the direction of the Bureau of Research in Education of the University of California. In making the survey the three problems of the preparation of the teacher, the content of the course, and the methods used were considered.

General science has been recognized by the high schools. There are 337 high schools in California and statistics gathered

by Mr. M. A. Rice of Ginn and Co. show that 92% of the high schools offer a course in general science. Furthermore all the universities of the State accept general science for entrance credit.

Early in Feb. 1921 a questionnaire was sent out to the teachers of general science in California. By the end of May replies had been received from 154 teachers, making approximately a 55% reply. The following table shows the results as to sex:—

	No. of teachers	Percentage
Male	85	55%
Female	69	45%
Total	154	100%

In order to collect and correlate the data from the questionnaires they were first divided according to the type of school they represented, placing all schools having an enrollment of 500 or more in Class *a*, those of 100-500 in Class *b*, and those of less than 100 in Class *c*.

Since the survey was made with reference to the three points,—the preparation of the teacher, the content of the course, and the method of general science, the results will be considered in these three groups.

PART I THE PREPARATION OF THE TEACHER.

One of the trite criticisms against general science is that it is not being taught by science teachers but by anyone to whom it may be assigned by the principal in his "final agony" in arranging the schedule of classes. In the past perhaps this was true but the results of the questionnaire show that, in California, general science is being taught by science teachers who have had a fairly broad preparation in science, since 56% of them teach science only and 81% teach science with or without any other subject. Of the remaining 17% a large number have the combination of general science and mathematics and probably as well trained for science teaching as many of those among the 81%.

Every teacher of general science should have specialized in one or more of the following subjects: chemistry, physics, or a biological science, either botany or zoology and should have made a study of at least the elements of three other elementary

sciences such as biology, physiology, zoology, physical geography, geology, astronomy, and anatomy.

The results point out that 85% of the teachers have this required specialization and that 95% of the teachers in the schools of class *a*, 88.6% of the teachers in the schools of class *b*, and 80.6% of the teachers in the schools of class *c* have studied six or more of these elementary sciences.

But the teaching of general science requires also a knowledge of certain applied sciences, such as bacteriology, entomology, forestry, mineralogy, and agriculture. Every teacher of general science should have made a careful study of one or more of these sciences.

That the teachers have a fairly good preparation in these special sciences is indicated by the fact that 71% of the teachers in class *a*, 62.4% in class *b*, and 53.6% in class *c* are prepared in three or more of these sciences. The class *a* schools both in this regard and in the preparation in the elementary sciences naturally have the more experienced and better trained teachers.

The following are suggested as the requirements for certification for a minor in general science:

1. Prerequisite for certification:—

Major in one of the following: chemistry, physics, botany, zoology.

2. Courses:—

(a) Teachers course in general science.

(b) A general (laboratory and lecture) course in three of the following: astronomy, biology, botany, chemistry, physics, geography (physical), geology, physiology, zoology (not including the major).

(c) A general (laboratory and lecture) course in one of the following: agriculture, bacteriology, entomology, forestry, meteorology, mineralogy.

General science will naturally be a minor but, as the above outline shows, should be accompanied by a major in one of the four sciences named as prerequisites. However, certification in majors or minors will not have full meaning until the teachers certificated are limited in teaching to the majors or minors in which they are prepared as is suggested by Will C. Wood in the 29th Biennial Report of the State Superintendent of Public Instruction.

Given this technical training in the sciences, a teachers course in general science, a general training in English, the social sciences, psychology, and pedagogy, along with a reasonable amount of common sense and the teacher ought to be successful in handling the course in general science.

PART II THE CONTENT OF THE COURSE.

In order to learn something as to the content of the general science course data were gathered regarding the text books in use. Even in general science the text book will always be an important factor. The majority of the teachers do not have the time to work out independent courses based on references and the average teacher does not have the ability to do so. A study of the text books in use gives a fair notion of the content of the course.

TEXT BOOKS IN USE

Name of text	No. of teachers scoring				
	School class	a	b	c	total
General Science					
Caldwell and Eikenberry	7	23	19	49	
Everyday Science					
Snyder	14	20	14	48	
General Science					
Lake	1	6	3	10	
General Science					
Elhuff	1	5	4	10	
Elementary General Science					
Hodgdon	5	3	1	9	
The First Year of Science					
Hessler	4	3	0	7	
An Introduction to Science					
Clark	2	3	9	5	
Introduction to the Study of					
General Science					
Smith and Jewett	0	3	2	5	
Science of Home and Community					
Trafton	0	2	0	2	
First Course in General Science					
Barber	0	1	0	1	
The Science of Everyday Life					
Van Buskirk and Smith	1	0	0	1	
No text used—original outline and references	4	3	0	7	
Totals	39	72	43	154	

One of the questions called for a "list of ten words of general scientific interest which a pupil having completed the course in general science should be able to answer." The vo-

vocabulary lists brought in a total of 335 words only 12% of which were repeated 10 times or more. This showed a great lack of uniformity of emphasis which might have been less marked if the number of words asked for had been greater.

However the vocabulary lists showed that there is a tendency to build up the course about the principles of the five sciences—biology, physics, physical geography, chemistry, and astronomy, laying especial stress upon the first two.

The following table, giving the number of words in the list and the percentages representing each of the five sciences mentioned above, contains results which are of especial interest because of their close resemblance to the results obtained by Trafton when he examined seventeen texts in general science from the standpoint of content.¹

Science	No. of words	percentage	Trafton's results (% of pages in 17 texts)
Astronomy	20	5.9%	2.9%
Biology	122	36.4%	38.7%
Chemistry	33	9.9%	10.3%
Physics	113	33.7%	33.5%
Physical geography	47	14.1%	14.6%
Totals	335	100.00%	100.00%

The results of the questionnaire and a study of the latest texts show that there is a tendency to get away from that type of *general* science which simply aims to introduce the pupil to the elements of the various sciences. A standardized course in general science is being built up about certain well defined principles of everyday life such as:—

1. The air:—its properties and uses.
2. The water supply and sewage disposal.
3. Food:—sources, functions, etc.
4. The weather.
5. Heating and ventilation.
6. Principles of lighting.
7. Protection.—home and clothing.
8. Health and sanitation.
9. Science of commerce and industry.
10. Life problems:—reproduction, heredity, selection, etc.

General science is thus becoming a *specialized* science and is giving up the term *General* science to acquire the name of *Civic* or *Environmental* science.

PART III THE METHODS IN GENERAL SCIENCE.

General science should be taught, as far as possible, by the inductive method, making large use of the laboratory, which may be a room in the school building, a factory, a garden, the open fields, or any place where thru investigation and experimentation the pupil may gain a knowledge of science and scientific methods.

The questionnaire showed that, as a rule, the teachers have no set number of periods per week set apart for laboratory work but let the use of the laboratory depend upon the nature of the problem under consideration. The most popular arrangement of periods for laboratory work seem to be divided between two 40 minute periods and two 80 minute periods per week. To be really effective general science must be accorded the same type of schedule which is usually given to chemistry and physics. A single 40 minute period is not sufficient time for the pupil to perform an ordinary experiment, draw his conclusions, and record the results.

A mixed schedule of three 40 minute periods and two 80 minute periods per week would make general science a real laboratory science. This plan has been made possible thru the installation of a schedule of classes which allows all first year classes a mixed schedule of single and double periods which so overlap that there is no conflict.

For example, general science and community civics could be placed on the schedule in such a way that there is one period separating them. This period could then, on certain days be added to the general science period and on other days to the community civics period to be used by the latter class in preparing reports, surveys, etc. Of course there arises a conflict as to which class will get the odd day but it could arbitrarily be assigned to either class or an arrangement of alternate weeks could be made to equalize the time.

But, granted a liberal time for laboratory work, the general science course will always be handicapped until special general science laboratories are provided and equipped with suitable apparatus and with shop conveniences where apparatus can be constructed by the teacher and the pupils. Many teachers placed this as the greatest need that they had in order to make their work more successful. Trying to work in the

chemistry or physics laboratories and using their apparatus is far from satisfactory, especially where general science is not taught by the same teacher as chemistry and physics.

The newer buildings have met this need but to make the work more successful the other schools must provide general science laboratories.

The body of the course in general science must be a set of projects and experiments which have been carefully planned so as to develop certain facts and principles rather than simply to supplement and illustrate the text or reference materials. The latter should be used, as far as possible, merely to aid in the discussion which follows the investigation and experimentation in the laboratory or field.

One of the greatest problems in method is the use of projects. Altho the questionnaire showed that a large percentage of the teachers were using projects yet there was considerable misunderstanding as to their meaning.

Perhaps the best definition of a project is that it is "a problematical act carried to completion in its natural setting." Dr. C. R. Mann says that a project may be characterized (1) "as a desire to understand the meaning of some fact, phenomenon, or experience. This leads to questions and problems. (2) A conviction that it is worth while and possible to obtain an understanding of the thing in question. (3) The gathering from books, experiences, and experiments the needed information to answer the question at hand."

The project is an excellent means of motivation in class work. Having successfully completed one project, the pupil will want to solve others and will thus have made a step towards acquiring that scientific attitude and interest which will make texts useless except as valuable books of reference.

Projects may be classified, according to the method of procedure, into four groups, namely:—surveys; collections and exhibits; observational and experimental projects; and constructional projects. A list of characteristic projects which are being used by the teachers of California is appended. Another valuable list is found in the Report of the Committee on the Reorganization of General Science in Minnesota.¹

The text, *The Science of Everyday Life*, by Van Buskirk and Smith (Houghton, Mifflin Co.) is not only worked out on the project-problem plan but gives suggestions as to a number of

individual and class projects. Snyder has lately added a set of home projects to his text, *Everyday Science*. (Allyn, Bacon Co.)

In a carefully planned course all the work will be grouped under certain projects, the solution of which depends upon the collection of certain data through a series of problems. For example, the project, "What is the relation of air to fire and breathing?" might be solved through a series of problems based upon the burning of a candle; the composition of air and the properties of the constituents; products of the combustion of wood; fuels—kinds, sources, etc.; breathing—the air we breathe in and the air we breathe out; physiology and hygiene of respiration and its relation to the circulation; artificial respiration.

Too great a school use of the "hit or miss" type of home project, such as, the removal of stains, softening of water, repairing of electrical appliances, etc., is not advisable, unless an attempt is made to understand the underlying principles, and unless they are definitely related to the larger projects of the care of the clothing, the home water supply, etc. Without such a relation they are apt to become superficial because they are based on the passing whims and fancies of the pupils.

However, the schools should encourage the pupils in definite and more or less extensive home projects which they themselves have purposed and which lead to results of real value. For example, if a boy is working on wireless at home, or is interested in the raising and breeding of rabbits, he should be encouraged and helped in such a project. If a girl has an interest in a home garden, the raising of certain type of plant, such as a chrysanthemum, she too should be encouraged and helped. Those pupils who have no interest or hobbies should be studied and if possible, be led to become interested in some worthwhile project.

From time to time there should be consultations between the pupil and the teacher. When the project has been successfully worked out, each pupil should make a detailed report to the class, making use of pictures, diagrams, demonstrations, and exhibits. Nothing is more satisfying than accomplishment, its demonstration and appreciation.

The class as a whole should work out a limited number of special group projects. Every class in general science should

visit and make a detailed study of as many of the local industries as possible, such as, the gas works, the water works, the ice plant, factories, etc. A few well planned and carefully directed surveys should be made, such as:—(1) Community health and sanitation survey; (2) Agricultural survey of the community; (3) A general survey of the local industries; (4) Survey of the local sewage system. Every class, if so located as to make it possible, should collect, mount, and learn the common and family names of the local wild flowers. Certain pupils will find an interest in collecting rocks and minerals, or insects, or in preparing exhibits of local tree life, means of seed dispersal, etc.

The value of these projects, which take the pupil away from the artificialities of modern life, cannot be over estimated. In our efforts to make education practical we are forgetting to put into it those broader, humanizing influences without which life is sordid and narrow. In my work I have seen boys and girls, who were considered the "bad boys and girls" of the school, take on a new attitude after they have become interested in wild flowers, butterflies, etc.

The future general science course will, thus, be built up about certain well defined projects, aimed to give the pupil a knowledge of his environment, an idea of the use of scientific methods, and a greater understanding and appreciation of the laws and phenomena of nature. There is nothing new in the use of projects. It has been the method of scientists for hundreds of years and is found as an important factor in the development of all modern business, commerce, industry, and in facts, all phases of modern life. It should be the method of the schools.

PART IV A FEW SPECIAL SUGGESTIONS,

Finally, let us mention a few special factors which may prove of value in making the course in general science more worthwhile. Many interesting and valuable suggestions received through the questionnaire. A few of the best were as follows:

1. Have a question box into which during the week the pupils may drop questions of scientific interest and on Friday a few minutes can be used in discussing them.

2. Develop a school museum.
3. Have a science bulletin board upon which notices may be posted as well as articles of scientific interest.
4. Have regular periods during which scientific magazines and current scientific articles can be discussed. (Popular Science Monthly, science department of the Literary Digest, etc.)
5. Scrap books may be made featuring animals, plants, insects, glaciers, electrical contrivances, astronomical pictures, etc.
6. Organize each general science class into a General Science Club to meet regularly in order to take up the discussion of scientific topics of interest to the pupils.
7. Organize a strong General Science Teachers Association, both local and state-wide, to hold regular meetings at which the various phases of the work can be presented and discussed.
8. Develop a set of standardized pedagogical tests in general science.

A brief discussion will be given to each of the last three suggestions.

In "Democracy's High School" there could be no better training for the duties of citizenship than through the activities of a well organized club. Mr. F. W. Murphy in the *General Science Quarterly* for January, 1920, gives a very good discussion on "Science Clubs That Work." "One day each week the ninth grade classes in general science are conducted as clubs. As soon as the class comes in on that day, it becomes, let us say, The Edisonian Science Club, and is immediately turned over to the president of that club who takes charge and directs the activities of the club." Following the transaction of the regular club business, a talk is given by one of the members on some topic which has been previously chosen, such as:—Commercial aeroplanes; Lives of great scientists such as Galileo, Newton, Edison, etc.; radium; jelly making; is Mars inhabited? etc. Following the talk there is a general discussion. This gives an opportunity for the discussion and demonstration of the results of the special projects in such a way that they will have an added interest and meaning.

One of the greatest needs of education is for a higher professional spirit among the teachers. Our state and county

teachers associations are doing a great work in this line. But within them there should be more organizations of teachers in the various branches of the work. The general science teachers should be organized, both locally and state-wide, to meet regularly to take up and discuss the various problems of the work. Through such an organization much of the misunderstanding regarding the purposes, content, and methods of general science could be cleared up and a greater degree of standardization could be reached.

One of the problems, which today is of paramount interest to educators, is that of standardized tests. This problem has arisen through a realization that our methods of evaluating both the mental growth of the pupil and the worth of a given course in bringing about that growth have not only been very indefinite but extremely inaccurate.

Fairly successful tests have been worked out in such subjects as spelling, reading, writing and mathematics, but in science little has been accomplished. In the field of general science are found two tests: 1. "A Range of Information Test in General Science"¹ by G. M. Ruch of the University of Oregon; and 2. "A Standardized Test Information and Thought"² by Paul Maxwell.

There is a need for a great deal of research in this line. Through a committee of interested general science teachers a set of standardized tests in general science could be worked out to test the three mental characters especially developed through science training, observation, memory, and reason. Such tests would include not only a vocabulary test and various information tests but also carefully chosen *achievement tests* in observation and reason, such as Dr. Otis W. Caldwell used, in his survey of the science work of the Gary Public Schools.

In conclusion, let us say, that the general science course of the future will be a specialized course built up about certain civic and environmental factors, taught largely as a laboratory science by teachers who are specially trained for the work. Its purpose will not be to introduce the pupil to the various branches of science but to give him a clearer understanding of his environment and an increased ability to make use of this environment.

¹ General Science Quarterly Nov. 1919.

² General Science Quarterly May 1920.

Characteristic Projects Used by the Teachers of General Science in California

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(Classified according to the method of procedure)

I. SURVEYS

1. Visiting and making a detailed study of individual local industries, such as:—water works, gas works, ice plant, etc.
2. General survey of local industries.
3. Study of local water supply.
4. Study of local sewage system.
5. Study of local transportation facilities, land, water and air.
6. Community health and sanitation survey.
7. Agricultural survey of the community.
8. Survey of local irrigation and drainage projects.
9. The school ventilation and heating system.
10. Study of hydro-electric power site.
11. Survey of local harbor conditions and possibilities.
12. Scientific study of the conditions which have made (city name) the center of —————— industry in the United States.
13. A study of —————— County.
 1. Topography.
 2. Industry.
 3. Plant and animal life.

II. COLLECTIONS AND EXHIBITS

- a. Collection and study of local rocks and minerals.
- b. Collection and study of local wild flowers—pressing, mounting on cards or on simple herbariums, learning the common and family names.
- c. Preparation of an exhibit of local trees—photographs of characteristic trees, cross and longitudinal sections to show bark and wood, collection and preservation of flowers and seeds showing methods of seed dispersal, account of commercial use of the trees.

- d. Collection and preservation of insects, butterflies, and various other animals for private and school museums.

III. OBSERVATIONAL AND EXPERIMENTAL PROJECTS

- 1. Home or school garden.
- 2. Growing of some one plant.
- 3. Study of local soils—their characteristics, origin, uses, etc.
- 4. Observation and recording of local weather conditions and the correlation of same with cyclones and anticyclones.
- 5. Fertilizer experiments to determine the nature and amount of plant food needed for the growth of plants.
- 6. Tracing the movements of Venus, the Moon, etc. in relation to the earth.
- 7. Observations of and charting of the stars and planets.
- 8. Milk testing.
- 9. Human foods—simple tests, etc.
- 10. Preservation and sterilization of foods.
- 11. Textiles and simple textile testing—methods of dyeing, removing spots, cleaning, etc.
- 12. Identification and testing of acids and basic materials in the home.
- 13. The fly—life history, relation to disease, methods of control.
- 14. The mosquito—life history, relation to disease, how to control.
- 15. Development of human shelter.
- 16. Detailed study of an automobile from the standpoint of the four simple machines, the gasoline engine, ignition system, etc.
- 17. Experimentation and practice in photography.
- 18. Development of the embryo in an egg to the full grown chick.
- 19. Electrical appliances in the home.
- 20. Methods and practice in budding, grafting, and pruning.
- 21. The National Forest—history, establishment, location, methods of conservation, uses, etc.

22. Construction and care of a balanced aquarium.
23. Home planning and construction.
24. Study of electric bell systems and their installation.

IV. CONSTRUCTIONAL PROJECTS

1. Making an electric motor.
2. Making a telegraph line.
3. Making a bird house.
4. Making fly traps.
5. Making fireless cooker.
6. Making iceless refrigerator.
7. Making a bowl of Portland cement.

**Are Any Principles of Organization of General
Science Evidenced by the Present Textbooks
in the Subject? ¹**

ADA L. WECKEL, Head Biology Department, High School, Oak Park, Illinois.

General Science has existed for a number of years, and it has attained a legitimate place in the curricula of many of our best high schools. After long experimentation, an introductory course in the scientific study of common things is now generally recognized as an essential part of the educational opportunities of our secondary schools.

Since its introduction into the schools, enough time has elapsed to enable us to consider that the period of experimentation has passed. Out of these years of experimentation, some definite opinions have crystallized. These are indicated by the organization of the courses in the textbooks of General Science, and by the results which several investigators have obtained from questionnaires filled out by many of our best science teachers.

Many administrators, and some science teachers, too, are not aware of the uniformity which occurs in the content of the courses given in the textbooks of General Science. This uniformity is due, I believe, to the fact that the authors are agreed on the dominant aims and purposes of the subject. An exami-

¹ Paper read before the General Science Section of the Central Association of Science and Mathematics Teachers, St. Louis, Missouri, November 26, 1921.

nation of the prefaces of our best textbooks shows that the aims of the writers are essentially the same as those of the science teachers who replied to a questionnaire sent out by Mr. C. M. Howe of Hughes High School, Cincinnati in 1918, and to another sent out two years ago by a Committee on Reorganization of General Science of which Mr. Fred Barber was chairman and of which I was a member.

In the judgment of the eighty teachers of science who replied to Mr. Howe's questionnaire, the three leading aims in the teaching of General Science in the first year of the high school should be to give each pupil:

1. Understanding, appreciation, and control of his every-day *environment*;
2. Appreciation of the *applications* of science in industrial and social life;
3. A fund of valuable *information* about nature and sciences.²

The dominant *purposes*, then, of General Science as determined by these three leading aims is to give each pupil the greatest possible understanding, appreciation, and control of his every day environment; to acquaint him with some of the most important industrial and social *applications* of science; and to furnish as wide a fund of *information* about nature and science as time permits.

In the questionnaires sent out by the Committee on Reorganization of General Science, teachers were asked first to rank in order of their importance the three following aims:

1. The problem seeing and the problem solving aim;
2. The knowledge aim;
3. The appreciation aim.

Second, they were asked to rank in order of their importance six "additional aims" which were similar to the ones which Mr. Howe had previously used.

From the results obtained in this investigation, it was found that teachers ranked the first set of aims in the following order:

1. Problem seeing and problem solving aim;
2. Knowledge aim;
3. Appreciation aim.

² From C. M. Howe, Can and Should General Science be Standardized? *School Science and Mathematics*, March, 1919, pages 248-255.

From the six "additional aims," the three which were selected as being the most important were the same as the ones which Mr. Howe found were considered of first importance. The ranking of these three aims was also the same for both groups of teachers.

Prefaces in our textbooks in General Science indicate that the writers recognize the same aims and purposes as those given by the teachers replying to questionnaires. Mr. Trafton, for example, in Science of *Home and Community*, says: "Applications of science more and more dominate our lives—. Any sane system of education must see to it that boys and girls living in the midst of these applications, which form such an important part of their every day life, are educated in terms of this environment, in order that they may better appreciate it and adapt themselves to it." The authors, Mr. Barber and others, of *First Course in General Science*, believe that the primary function of first year general science is to give, as far as possible, a rational, orderly, scientific understanding of the pupil's environment to the end that he may, to some extent, correctly interpret that environment and be master of it. These and similar expressions which may be found in almost any one of the textbooks, indicate that the present day tendency is to give the child an understanding of those scientific problems which are vitally connected with his every day life.

Recognizing the unanimity which exists in the three basic aims: *environment*, *application*, and *information*, consideration may now be given to the selection and the organization of the materials presented in our general science courses. Writers of textbooks and teachers of science are also quite generally agreed upon the organization of the subject matter of general science. They believe that the subject matter should be organized around the *interests* and *experiences* of the pupils rather than around the principles and laws of any branch of science.

In the replies to the questionnaire sent out by the Committee on Reorganization previously referred to, eighty percent of the teachers expressed their preference for a course organized about natural units: those having some common process, or activity, or set of concepts functionally related to life, rather than about units having scientifically related principles as a core. In most of the textbooks the materials have been se-

lected from the pupil's environment and then organized from the *human* rather than from the *scientific* point of view.

The organization of any course in General Science will depend upon the selection of the materials for the course, and this selection in turn depends upon the aims of the course. With the aims so clearly defined, it is inevitable that the content of the courses as given in the textbooks, is very uniform. Many do not know how similar the courses are, and others, opponents of the subject, are not willing to recognize the fact.

In an effort to determine what underlying scientific principles and fundamental concepts occur most frequently, I have made a careful examination of the following fourteen text books:

1. Barber, First Course in General Science. Henry Holt Company.
2. Brownell, General Science. Macmillan Company.
3. Caldwell and Eikenberry, General Science. Ginn and Company.
4. Clark, An Introduction to Science. American Book Company.
5. Elhuff, General Science. D. C. Heath Company.
6. Hessler, The First Year of Science. Benjamin Sanborn Company.
7. Hodgdon, Elementary General Science. Hinds, Hayden and Eldredge Company.
8. Lake, General Science. Silver Burdett Company.
9. Pease, General Science. Merrill Company.
10. Snyder, First Year Science. Allyn and Bacon.
11. Smith and Jewett, Introduction to the Study of Science. Macmillan Company.
12. Trafton, Science of Home and Community. Macmillan Company.
13. Van Buskirk and Smith, The Science of Everyday Life. Houghton Mifflin Company.
14. Weckel and Thalman, A year in Science. Row, Peterson, and Company.

A tabulation of the results of this investigation is as follows:

FUNDAMENTAL CONCEPTS AND TOPICS WHICH OCCURRED IN:

I. All Fourteen Texts.

1. Atmospheric pressure
2. Principle of and kinds of thermometers
3. Definitions and applications of humidity, dew point, condensation, saturation.

II. Thirteen of the Fourteen Texts.

1. Oxidation.
2. Transference of heat: conduction, convection, radiation.
3. Soils, origin and composition.
4. Study of weather maps.

III. Twelve of the Fourteen Texts.

1. Composition of atmosphere.
2. Winds, cause of and general circulation.
3. Molds and bacteria: structure, development, relation to diseases and decay.
4. Foods and nutrition.

IV. Eleven of the Fourteen Texts.

1. Study of the cell.
2. Calorie, value of
3. Structure and function of parts of human eye.
4. Heat, nature and origin.
5. Electricity, elementary presentation of.
6. Sanitation and diseases: germs, toxins, antitoxins, disinfectants, sterilization, vaccines, etc.

V. Ten of the Fourteen Texts.

1. Seasons, cause of.
2. Gravity, definition.
3. Pumps.
4. Storms, causes and common types.
5. Sewage disposal.
6. Types of electric cells.
7. Lighting systems: kerosene, gas, electric, acetylene.

VI. Nine of the Fourteen Texts.

1. Properties of matter.
2. Elements and compounds.
3. Plants: structure and function of roots, stems, leaves, flowers.
4. Molecular theory.
5. Water power and its application.
6. Manufacture of artificial ice.
7. Steam engine, principle of action and application.
8. Sound, nature of.
9. Light, nature of and properties.
10. Carbon dioxide: source, role in nature, fire extinguisher.
11. Cell division and reproduction in plants and animals.
12. Machines: lever, screw, pulleys, wheel and axle, inclined plane.

13. Solution, especially as applied to hard and soft water.
14. Vaporization.

VII. Eight of the Fourteen Texts.

1. Drainage and irrigation.
2. Erosion.
3. Distillation.
4. Solar system.
5. Physical and chemical changes.
6. Heating systems.
7. Magnetism.
8. Acids, bases, and neutralization.
9. Injurious insects.
10. Osmosis.
11. Filtration.
12. Expansion of solids, liquids, and gases.
13. Electric bell, telephone, telegraph.
14. Ventilation, principle of and different systems.
15. Combustion.

VIII. Seven of the Fourteen Texts.

1. Siphon.
2. Human ear, parts and functions of each.
3. Weathering.
4. Fertilization.
5. Lenses, kinds.
6. Day and night, cause.
7. Capillarity.
8. Gasoline engines.
9. Plant nutrition.

IX. Six of the Fourteen Texts.

1. Metric system.
2. Density and specific gravity.
3. Archimede's principle.
4. Survey of animal kingdom.
5. Time, standard, etc.
6. Electrolysis.
7. Fuels and carbon compounds.

X. Five of the Fourteen Texts.

1. Human body, structure of
2. Energy: kinds, measures for.
3. Life processes in animals.
4. Pasteurization.
5. Properties of protoplasm.
6. Mechanics of respiration.
7. Pollination and fertilization in plants.

XI. Four of the Fourteen Texts.

1. Seed dispersal.
2. Glaciers.
3. Latitude and longitude.
4. Cohesion and adhesion.
5. Wind power.
6. Human voice.
7. Earthquakes and volcanoes.
8. Parasites and saprophytes.
9. River development.
10. Economic botany.

XII. Three of the Fourteen Texts.

1. Analysis and synthesis.
2. Boyle's law.
3. Hydraulic press.

Total number of topics listed above is eighty-nine.

Except for the phraseology and the time involved, no difficulty arises in a mere listing of the concepts given in textbooks. When one attempts, however, to analyze this subject matter, to place it in as few large units as possible, and to recognize the larger units most frequently used, his task becomes difficult.

After the selection of the materials from the child's environment has been made, writers frequently group it about one of two centers: either the *home* or the *community*; occasionally both are used. It is then further divided into such topics as atmosphere, water, methods of transportation, building materials, household chemistry, foods and nutrition, the universe, oxidation and its relation to life, and a multitude of others, all usually well chosen.

About the larger units or topics which I found occurring most frequently in text books, I have attempted to formulate what might be termed a composite course by placing under these topics the fundamental concepts and scientific principles which I found in the frequency which I have already given. If I have succeeded in doing this without personal bias and with any degree of skill, I should then have a standarized course based upon the courses as given in the textbooks which I have examined. Since a large number of representative books was examined, I think that I am justified in presenting the following outline as a standarized course in General Science based upon the courses developed by the text book writers, most of whom are or have been high school teachers.

OUTLINE OF STANDARDIZED COURSE BASED ON TEXTBOOKS

I

ATMOSPHERE

1. Physical properties and mechanics of gases
2. Chemical composition
elements, compounds, mixtures,
molecular theory of matter
Study of oxygen, nitrogen, carbon dioxide, oxidation
3. Atmospheric moisture
evaporation
humidity
4. Weather
air pressure
pumps
barometer
temperature
winds
storms
5. Respiration in plants and animals (Frequently included under IV)
hygiene of breathing
ventilation

II.

WATER

1. Physical properties
2. Chemical composition
solution
hard and soft water
3. Mechanics of liquids
4. Distillation
5. Evaporation
refrigeration
manufacture of artificial ice
6. Water supply
source
purification
7. Sewage disposal
8. House piping
9. Hot water heating (often included under VI)

III.
EARTH

1. Its relation to the universe
stars and solar system
earth and its seasons
2. Soil
origin
physical structure
erosion and sedimentation
fertility
soil water
drainage
irrigation

IV.
LIFE ON EARTH

1. Plants
cell, structure and activities
parts of plants and their functions
food production
food storage
reproduction
2. Animals
groups
human physiology (often omitted)
reproduction
insects and diseases
3. Bacteria, yeasts, and molds
human diseases
4. Hygiene and sanitation

V.
FOODS AND NUTRITION

1. Foods
need of
production
measurement of food—calorie
composition
2. Digestion
organs of
hygiene
3. Diet
4. Adulteration

VI.
MACHINES, WORK, AND ENERGY

1. Work of running water—water wheel, turbine, etc.
2. Work of simple machines
3. Measurements and kinds of energy
4. Heat
transmission of
fireless cookers
methods of heating our homes
coal
work done by heat—steam engine
5. Light
nature
color
human eye
methods of lighting our homes

- 6. Sound
 - nature
 - human ear
- 7. Electricity and magnetism
 - measurement
 - electric generators
 - applications of electricity
 - electric bell
 - automobile
 - telephone
 - telegraph

In presenting this outline, my paper is concluded so far as the problem assigned to me by your chairman is concerned. I can not refrain, however, from expressing a few convictions which have come out of the study made for the preparation of this paper and out of years of observation and participation in the General Science movement.

1. Many of the courses in General Science include more material than can be given to first year high school pupils in one year.
2. Relatively too much emphasis is being placed upon the physical environment of the child. More civic biology should be included in many of the courses.
3. The project method is not feasible for the overworked teacher, for the one who has very large classes, nor for the beginner.
4. The years of experimentation in General Science need not be looked upon with the disapproval and contempt so frequently evident, for often even inexperienced teachers give better courses when all initiative and interest have not been destroyed by overstandardized courses.
5. There is a surprising unanimity in the aims and purposes of General Science and also in the subject matter included in the courses now given.

Reform of Science Teaching in America¹

G. H. J. ADLAM, Editor of School Science Review, City of London School.

The publication by the United States Bureau of Education of a bulletin on reorganization of science teaching in secondary schools² suggests a comparison between English and American aims and methods, so far as this comparison can be made by one who has had first-hand acquaintance only with English schools. The bulletin is authoritative; it embodies contributions and criticisms of "more than fifty science teachers and administrative officers," and much of it, especially the general science introduction, has been put in force. The report was approved by the reviewing committee of the Commission on the Reorganization of Secondary Education. This approval can be taken as implying essential agreement with the general recommendations.

It is a well-known trait of Americans to discard obsolete systems, just as they scrap inefficient machines, without saying much about them afterwards. The character of the system which called for reorganization has therefore to be picked up from remarks dropped here and there; it is, however, expressly stated that there was widespread recognition of the need of a change.

Early specialization comes in on the first page. This, in the words of the report, "diminished the value of instruction from the standpoint of the general needs of the pupils and the needs of society." The secondary course was drawn up by specialists, and regarded merely as an introduction to more advanced work, and while presenting the so-called essentials with their definitions and classifications, subordinated or left out altogether "the commonplace manifestations of science in home, community, civic, and industrial situations." Successful reorganization is made more difficult by the narrow point of view of those persons who see in the movement an opportunity to advance the particular branch of science in which they are

1 From School Science Review, London, June 1921.

2 Reorganization of Science in Secondary Schools; Bulletin 1920, No. 26; Government Printing Office, Washington, D. C. Price 10 cents.

most interested, and to demand for it a larger proportion of the pupils' time.

It is necessary at the outset to grasp the American idea of the function of secondary education. It is to promote the health of the nation by disseminating knowledge and practice of the basic principles of personal hygiene and public sanitation; it is to make home life comfortable and attractive, and to contribute both to vocational guidance and to a broad preparation for vocation. It is to give a greater appreciation of the responsibilities of citizenship; to teach the proper use of leisure, and to develop the ethical character by establishing a more adequate conception of truth and a confidence in the laws of cause and effect. In addition to these general aims, science is intended to develop many and varied interests in its own field, to teach effective and satisfying methods of solving problems, to stimulate the pupil to "more direct and purposeful activities," and to give him control of a large body of facts and principles.

The dualism that would classify subjects as cultural or non-cultural, humanistic or scientific, aesthetic or materialistic, with an implication of the inferiority of the latter to the former, is, as the report says, dying out. It is laid down categorically that "all subjects are cultural in the degree to which they develop wider appreciations of the worth while" (this is typically American); and "all subjects are aesthetic in the degree to which they open the eyes to the perception of new beauty and increase the power to understand and enjoy."

To English readers some of this may seem a little "toplofty" and lacking in intellectual aspiration; nevertheless, it contains much common sense, likely to appeal to a business-like nation that provides the cash and expects to have the goods delivered "as per sample."

There is one important question which, so far as the writer knows, English teachers have not discussed, but which American teachers have definitely settled in their own minds. Supposing the intellectual development of young American citizens and the advancement of pure science seem to be incompatible, which is to give way? In the words of this report, "The science courses should be so organized as to constitute the best training for that period, regardless of any further science courses that the pupil may take." It should start with questions of immediate interest to the pupil, ideas which are significant to him

by reason of his own experience and which concern his own life to such an extent that he perceives, or is easily led to perceive, their "worthwhileness."

Coming now to general considerations governing the selection of the introductory course, we ought first to notice the psychological basis of education as it appears to the American teacher. It is summed up as follows: (1) Self-activity is a law of growth; (2) interest secures attention and makes self-activity possible; (3) interest, to be sustained, must rest on the perception of the worthwhileness to the individual of the purpose sought. Admitting the fundamental importance of "worthwhileness," the American teacher is inexorably led on to the science of common things, or general science, as the most suitable introduction for schoolboys up to a certain age.

Before considering what is taught and how it is taught, it is necessary to explain the terms "project" and "topic," which occur on almost every page of American pedagogic literature. The project, as defined in this pamphlet, is "any projected activity or experience which an individual proposes to enter upon or carry through to the end." This does not get us much further than Sydney Smith's definition of an archdeacon; it might mean a burglary or a game of patience. Dr. John A. Stevenson, who, in *School Science and Mathematics*, deplores the ambiguity of existing definitions of a project, gives his own as follows: "A project is a problematical act carried to completion in its natural setting." Evidently the term "project" started life as a catchword, but, being much too good a find to be allowed to go a-begging, has had a concept fitted to it, and, so far as can be judged from illustrations given, a project appears to be a problem which, as Americans say, "gets down to brass tacks."

The important words in Dr. John A. Stevenson's definition seem to be "in its natural setting," for the project is probably the antithesis of the academic problem, which is an end in itself. To make an electric motor is a project, and to rid a community of mosquitoes or houseflies is also a project. A boy who tests seeds is only doing a problem, but a boy who determines to test his father's seed corn as a part of school work has found a project. Similarly, to determine the specific gravity of a liquid is merely an exercise, but to find out whether the milk delivered at the door has been watered is a project.

Related projects constitute a topic, and a group of "unified topics" forms the basis of an introductory science course. Lack of space prevents our going fully into the principles that are to guide the choice of topics and projects. It is sufficient to say that they must be related to everyday experience, and their "worthwhileness" must be either self-evident or easily demonstrated.

* * * * *

The teaching is to be based on reformed laboratory work. According to the bulletin, this has not hitherto produced the results expected. "Experiments are too frequently devised to check up and prove generalizations or laws the truth of which the pupil already perceives." "They often repeat work described in the text in such a way that the outcome is uninteresting and of little value." The laboratory should not be a place where directions are followed blindly and meaningless results are obtained. The project is to be dealt with by the true scientific method—the recognition of a question to be answered, the framing of hypotheses, the testing of the most probable hypothesis and its adequate verification. This is the heuristic method applied comprehensively instead of in detail.

As to classroom procedure, the committee remarks, "We find the teacher alone active, the class passive; the teacher dominant and aggressive, the class repressed and attentive only in a receptive, not in a co-operative sense." "The 'hearing of lessons,' memoriter repetition of facts, the more or less discontinuous dialogue between teacher and individual pupil, should give place to real class discussions, in which all take an active part in contributing, organizing, and using the information dealt with."

The demonstration experiment is to play an important part. It has many of the merits of individual effort without the confusion due to poor manipulation, or the failure to observe the most important aspects of the experiment. Pupils should be encouraged to assist in these. Notebook tyranny is to be moderated, for as the bulletin pointedly remarks, "an experiment is not designed for the sake of the notebook record." A feature of the course should be definite instruction in the use of the textbook as the principal reference book, to be supple-

mented by magazine articles, newspaper cuttings, official bulletins, and the science library.

It is hard to foresee how this classroom procedure would work out in English schools. The English boy is probably shyer and more diffident than the American: besides, there is tradition which ordains that you may be a "swot" if nature biased you in that way, for you cannot help it; but to be an aggressive "swot" is quite another matter. Again, that delightful but subtle sense of humour in the British boy would be a factor to be reckoned with. One can hardly imagine an English schoolboy meticulously labelling a demonstration experiment "performed by the instructor."

Schemes of instruction for various types of school are given. For the four-year high school of medium size the following is prescribed:—

First Year.—General science, including hygiene.

Second Year.—Biological science, including hygiene; courses may consist of general biology, botany, or zoology.

Third Year.—Chemistry, with emphasis on the home, farm, and industries.

Fourth Year.—Physics, with emphasis on the home, farm, and industries; general geography or physiography, or advanced biological sciences.

Biology in the second year still follows the problem-project-topic method in preference to the specialist courses in morphology and classification. Herbaria of dried specimens, which formerly "cluttered home and school," are to be swept away; indeed, the main points seem to be that biology should become a study of living rather than dead organisms, and that even the well-appointed laboratory should be regarded only as a reasonably good substitute for out-of-doors.

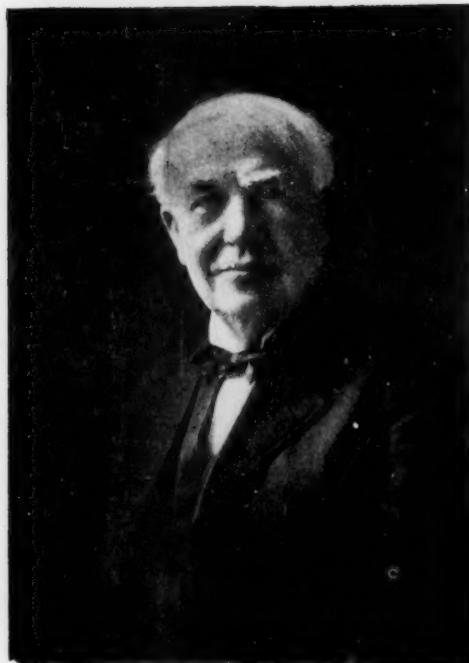
Of the special or elective biological courses of the fourth year not much is said, except that the study of invertebrates should not consume more than half the course. Botany will teach the principle of soil replenishment by living organisms large and small, soil sterilization, and soil inoculation. There will be more practical work with plants as in forestry, tree-planting, tree surgery, pruning, grafting, budding, artificial pollination, plant breeding, and so on.

The special elective chemistry and physics courses probably

are not meant to differ much from our customary courses, except that from the descriptions they seem to be intended to be more vocational and less philosophical; thus, courses in household or domestic chemistry, courses in "technical curriculum," chemistry for nurses, for electroplaters, for pharmacists, for workmen and foremen in chemical industries are given as examples.

In this report there is, as Dr. Johnson once rather inopportunely put it, "a bottom of good sense"; there is also much to which we should hesitate to subscribe, for in places, if the surface is ever so lightly scratched, the trail of the dollar is revealed. There appear to be temperamental differences between English and American teachers and different standards of evaluation. Americans have not got our simple faith in the secret growth of the seed; they like to see things moving; hence, to them the absence of manifest self-activity means stagnation. We know that this is not necessarily true in things appertaining to the spirit from the very bad showing that many of the world's greatest geniuses have made in early years. The English boy is not given to airing his knowledge; his nonchalance is, in part, a little bit of pose, in part a concession to schoolboy etiquette. His "self-activity" becomes evident enough when the occasion calls for a little leg-pulling.

Nevertheless, in endeavoring to get a boy to reveal himself early, and in giving him every opportunity of doing it, the Americans have chosen more wisely than we. Their system makes for a wider dissemination of usable scientific knowledge than ours. The intellectual barrenness of chemistry and physics prescribed for the third and fourth years is not the logical outcome of general science in the first year, but only a case of pressing "the logic of a fact to its ultimate conclusion in unmitigated act." The danger of superficiality is fully recognized, but the risk is cheerfully accepted to secure self-activity and self-educative effort rather than apathy, which it is firmly believed has been the outcome of the introduction of a "diluted college course" into schools.



Edison from his latest picture.

The Birth of the Incandescent Lamp

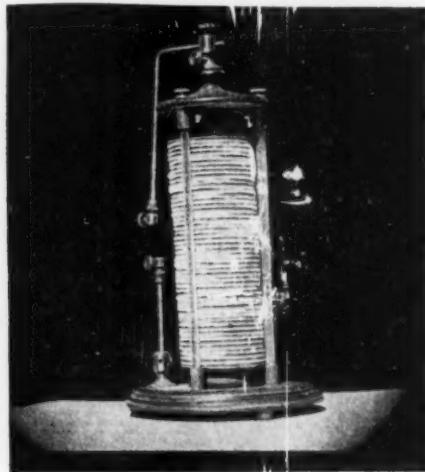
By HENRY SCHROEDER, Edison Lamp Works, Harrison, N. J.

October 21, 1921, was the forty-second anniversary of the "birth" of the incandescent lamp, invented by Thomas A. Edison at Menlo Park, N. J., in 1879 when he was thirty-two years old.

Edison had a well equipped laboratory and a corps of more than loyal assistants. He had made a number of notable inventions and it was in 1878 that he tackled the problem of "sub-dividing the electric light," which was then being discussed by scientists the world over, many claiming it to be impossible. In order to appreciate the difficulties he was up against, one should understand what was known of electricity at that time.

The first method of obtaining electricity in reasonable quan-

tities was by chemical means. In 1800, Alessandro Volta made a pile of silver and copper discs laid alternately with pieces of cloth, wet with salt water, between them. This was known as the Voltaic Pile and was the forerunner of the present-day battery. It is fitting, therefore, that the VOLT, the unit of electrical pressure, is named in his honor.



Voltaic Pile.

In 1810, Sir Humphry Davy first demonstrated the electric arc before the Royal Society in London, using a voltaic pile for his source of current.

Various inventors made arc lamps, the first commercial installation being in a lighthouse in 1858 using a dynamo, having permanent magnets for field poles, as the source of current. The use of electromagnets increased the output of dynamos, so that by 1878 arc lighting was beginning to be well established.

The arc light was mainly used for street lighting, as it gave too much light for the illumination of small areas, such as homes, offices, etc. Thus, at this time, the problem of "subdividing the electric light," as it was popularly called, was naturally engrossing the attention of scientists and inventors the world over.

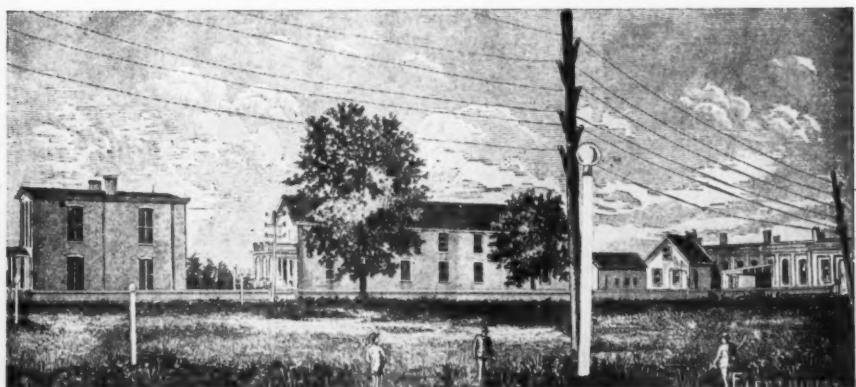
Several inventors had made incandescent lamps, most of which consisted of carbon rods heated to incandescence in a

partial vacuum or in an inert gas to prevent the carbon from burning up. None of them were successful as they could not be made to last a reasonable length of time.

Edison, realizing this, began experimenting with platinum. Others had tried it, but had been unable to get much light from it as it became incandescent only when operated very close to its melting temperature and so would easily burn out. Edison,



Edison's First Lamp Factory at Menlo Park.



The First Trial Installation of Incandescent Lamps at Menlo Park.

by making a platinum-iridium alloy made some improvement, and by means of a thermostatic arrangement, prevented the burner from melting by cutting off the current when it became overheated.

Edison also realized that he must keep down the size of the distributing wires as otherwise their cost would be prohibitive in a complete lighting system. To do this the current must be low, and as the power delivered is the current times the pressure (amperes \times volts = watts), the pressure must be high. If the pressure be high, a lamp to consume a small amount of power must have a high resistance. For example, assume a lamp consumes 100 watts (about one-eighth of a horse power). If the pressure were 10 volts the lamp would require 10 amperes, as 10 volts times 10 amperes is 100 watts. Ohm's law is

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

hence this 10-volt, 10-ampere lamp must have a resistance of 1 ohm. If the pressure were 100 volts, a 100-watt lamp would require 1 ampere instead of 10, and must have a resistance of 100 ohms instead of 1.

Edison therefore reasoned he must have a high resistance lamp for a practical multiple system. By winding several feet of fine platinum wire on a spool he obtained a high resistance and such a lamp looked promising, but it was expensive and would not last very long.

Knowing that he could obtain sufficiently high resistance with a long and extremely thin thread like piece of carbon, he thought that it might be made to last at the high temperature of incandescence if it were operated in an extremely high vacuum. He proceeded to develop a vacuum pump and by means of a combination of the Sprengel and Geissler mercury pumps was able to produce the very high vacuum desired. The next problem was to maintain this very high vacuum which he realized could only be done by a one piece, all glass, globe, all joints being hermetically sealed by melting the glass together.

He designed such a lamp, using platinum wires, which expand at the same rate as glass and therefore would make an air-tight fit, to go through the glass and connect with the threadlike carbon inside. The carbon was to be fastened to the platinum wires by delicate screw clamps, the wires in the



Courtesy of New York Edison Company.

Photograph Taken by Major Hamilton Maxwell.

Forty years ago in the narrow streets of Lower New York, now overshadowed by these giant structures, Thomas A. Edison laid the foundation for the electrical system which now supplies New York City.

meantime having been inserted in a piece of glass tubing after which the glass was to be melted together at one end around the wires to make it air-tight. This was then to be inserted in a globe, one end of which was to be open so that the glass tube with the threadlike carbon could be inserted. The edge of the hole in the globe was then to be melted to the glass tubing thereby making it completely air-tight. At the other end of the glass globe a small hole was to be made and a piece of small glass tubing was to be melted to it, the tube to be connected with the pump so the air could be pumped out of the globe. After this, the small tube was to be melted off, sealing up the globe so that then there would be a one-piece glass globe entirely surrounding the threadlike carbon after the air had been pumped out.

Having designed the lamp, the next problem was to make the threadlike carbon. He took some ordinary cotton sewing thread, packed it in a crucible to prevent outside air reaching it and put it into a furnace. There it was heated for several hours, which drove off all the volatile matter, leaving nothing but carbon behind. This operation is known as carbonizing. He finally obtained a filament, as he called it, after several trials, and made a lamp.

This was October 21, 1879, and bets were made among the workmen that the lamp would not last. Amid much excitement the lamp was connected and current gradually turned on. The lamp lighted up and all watched it. It continued to burn, the excitement growing more intense. The lamp lasted for forty-five hours.

Every conceivable thing was carbonized and tried out for a filament. Cardboard paper was found, after several weeks' work, to be the best, and many hundreds of lamps made and tried out with success. A public demonstration was decided upon. Wires were laid underground and connected to over a hundred lamps on wooden poles located on the country roads for nearly a mile in all directions about Menlo Park. Announcement was made in the New York Herald of December 21, 1879, of the successful invention and of its demonstration to the public during the Christmas holidays. Crowds came out to see the new light, the demonstration proving that the lamp was a success.

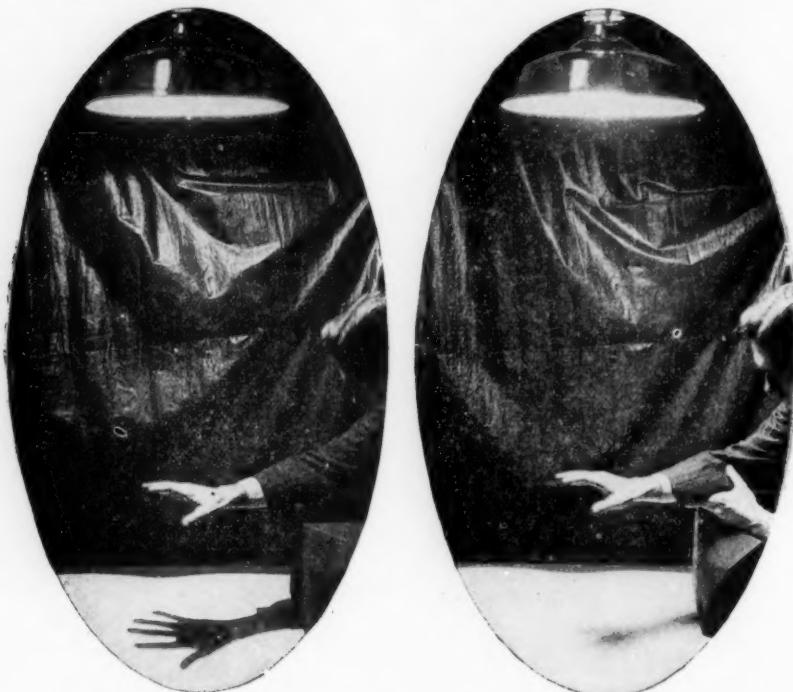
The Edison Sales Builder.

New Lamp Reduces Glare

By H. F. BARNES, Harrison, N. J.

The accompanying pictures were taken during an experiment run at the Illuminating Engineering Laboratories of the Edison Lamp Works, in Harrison, N. J.

First, an ordinary clear MAZDA C lamp was inserted in the reflector socket, the current turned on and into the flood of light one of the engineers stretched his hand—a shadow was naturally produced.



The clear lamp was then removed and a Bowl Enameled MAZDA C lamp inserted. The engineer again stretched out his hand under the unit—the shadow had practically vanished.

Both reflector and hand were in the same position as before, the lamp only had been changed.

Bowl enameling redirects most of the light of the brilliant filament up into the reflector, making the light come from the whole reflector, in many directions, instead of from the tiny filament itself. It makes each reflector a small window.

"Bowl enameled" means that the lower half of the glass bulb of the MAZDA C lamp has been sprayed with a thin, white hard enamel.

The enameling is easily cleaned and will not chip, crack or discolor.

This lamp should be used with any make or style of steel reflector (with the possible exception of deep bowl and angle types where the pocketing of the light reduces the total efficiency).

The lamp can also be used with certain types of glass reflectors.

Motor Fire Apparatus

By A. C. HUTSON

The development of the automobile industry has had probably as marked an effect on fire service as any other individual feature. The location and distribution of fire apparatus is limited by the ability of the motive power to get it to the fire within a reasonable time. With hand-drawn equipment, fire stations were practically all located in the business districts, leaving outlying sections unprotected. As towns progressed, they hired or purchased horses, and it was then possible to distribute the companies over a wider territory and still be able to concentrate the apparatus in the center of the town where it was needed for large fires.

Automobile apparatus has introduced several marked changes. It has permitted wider distribution and protection by a less number of companies, estimated by the National Board at 85% of that necessary for horse-drawn, and has opened up a broad field of mutual aid from adjacent communities. It is assumed that thirty to thirty-five miles an hour is a safe maximum speed for city operation; for country roads a greater speed can be allowed, but it is not thought that the fifty to sixty miles an hour attempted by some makers of apparatus is proper for any type of apparatus which may be called upon to respond in all kinds of weather and with

poor road conditions. With all automobile apparatus the maximum speed can be maintained for an indefinite period, thus it is possible to consider practically any apparatus within thirty minutes running distance of a business district as being readily available for fires in that district.



Fire Fighting Methods in the Seventeenth Century.

The National Board, in applying its Grading Schedule to fire departments, considers all fire apparatus within the city limits as constituting protection to the business district, and outside aid equipment which is within thirty minutes running distance is also of value with automobile equipment. This will include as part of the protection of a city practically all out-

side motor fire equipment within a radius of fifteen miles of a town.

It is believed the greatest feature of motor equipment is in the development of a scheme of mutual aid, by establishing fire districts in rural sections. With a city of 5,000 to 15,000 population as a center, a fire district can be established em-



Modern Motor Driven Fire Apparatus in Action.

bracing a whole county, or some specified area, and equipment can be so located that the response of two or three pieces of apparatus will be practical at any fire without a delay exceeding thirty minutes for the last piece to arrive.

HORSES WERE "Winded"

One of the best examples of the advantages of automobile equipment over horse-drawn was the experience in the Atlanta conflagration, which was preceded by three fires, all in the

same section, in a somewhat outlying part of the city. Much of the equipment had to travel the entire length of the city, and the horses at the end of the run were played out and could not travel much faster than a walk. Under these conditions there was considerable delay in getting the horse-drawn equipment to the last fire and ahead of the conflagration. In fact, some automobile equipment from out of town reached the fire ground ahead of the city equipment.

Fire apparatus must be dependable; prior to 1910 the defects in the automobile were too marked to permit fire departments making large use of it. The first type of automobile perfected was the passenger-carrying type. It was recognized that these passenger cars were too light for fire department operation, so that their use was restricted largely to conveyances for getting men to the fire. These consisted of cars for chief officers and cars for taking a body of men, known as an auxiliary squad, to a fire to help under-manned companies.

With the general use of motor equipment, there is less need for these flying squads; the delay in calling in outlying companies is not great and therefore it is considered preferable to give a stronger individual strength to all the high value companies, and to depend on apparatus which would respond to second and greater alarms to provide the necessary men for a severe fire.

In 1908 a pump was successfully mounted on an automobile with the necessary gear and clutch connections to permit its being operated at a fire by the same motor which brought the apparatus to the fire. This first machine was rather crude and was overrated; with its introduction the National Board realized the value of proper performance and evolved a set of specifications and tests which would assure equipment of adequate capacity.

ENDURANCE TEST

In 1910, '11 and '12, at the annual convention of the International Association of Fire Engineers, official tests were made of automobile pumping equipment; these tests were conducted by the National Board's engineers. At that time it was considered a fairly satisfactory test if a continuous run at full capacity could be attained for a period of twenty minutes. At the convention of the International Association of Fire Engineers held in New York in 1913, it was decided the reliability



Practice With Fire Equipment.

of motor equipment should be proven, and a twelve-hour endurance test was specified. Through the high standard required by the National Board in its test specifications there has been a continuous improvement in pumping engines, until today they far surpass the old steamer in their capability to deliver water for long runs.

In the early days of motor equipment, hose wagons were the principal pieces purchased. For several years it was quite common practice to buy tractors and install them on existing steam fire engines and ladder trucks. It is recognized today that it is not economy to tractorize a steam fire engine and often the ladder trucks of the slow-raising type are not worth tractorizing. One leading manufacturer of tractors has recently discontinued his business. A study of the output of a leading manufacturer of fire appliances shows that up to the end of 1915 hose wagons and pumper were sold in about equal amounts. Beginning with 1915, the number of pumping engines sold increased at a rapid rate, and at the end of 1918 amounted to about three times the number of hose wagons sold. It is recognized today that even though the city water system may be at pressures which would give good effective hose streams, it is on the side of safety to provide pumping capacity, and as this pumping capacity can be obtained on motor apparatus without excessive cost, and does not add much to the weight, pumper are preferable to hose wagons.

The main feature in connection with motor equipment is the operating force. Much trouble is experienced from attempts to adjust the carburetor or rearrange some other part of the machine, and it is only after the firemen realize that the average car needs little of this so-called adjusting that satisfactory service can be expected.

The question is often asked as to whether it is not cheaper and equally satisfactory for a city to buy a commercial car and adapt it for fire service. Experience has shown that many changes are necessary before a commercial car can be satisfactorily used by a fire department. Fire service is very distinctive and severe. Response must be made in all classes of weather, at all times of the day or night; the machine travels at high speed; it must stop and start quickly to prevent accidents, and it is often handled by men who have had little experience in driving cars.

During severe winter storms there has been trouble from motor fire apparatus stalling in the snow and sleet. Some cities and towns have found it necessary to go back to horse-drawn equipment and the old-fashioned pung or sleigh. While the experience has been rather unfortunate, it is not believed that it is necessary to maintain horses and horse-drawn equipment for such an emergency; rather it would appear to indicate that there must be some changes in the type of tire on the wheel or method of preventing the skidding of the wheels in such snow.

Safeguarding America Against Fire.

The Latest Altitude Record

Lieutenant Maeready succeeded in attaining a world altitude record in aviation, September 28, 1921, by ascending in an aeroplane to a height of 40,800 feet at Dayton. This distance of approximately eight miles up into the air far exceeds the altitude record secured by Schroeder about one and one-half years ago, when he reached a height of slightly more than 38,000 feet. These performances are looked on by most persons as essentially feats of skill and endurance, combined with exceptionally successful mechanical perfection of the flying apparatus. To the medically trained who bear in mind the limitations of the human machine at high altitudes, these aeroplane records awaken appreciation of scientific acumen and technical ingenuity in overcoming the handicaps which unaided nature has placed upon man as a flying animal. High altitudes or low barometric pressure are well known to interfere with physiologic functions. What is true of mountain sickness is equally applicable to the other more modern forms of altitude sickness which the balloon and subsequently the aeroplane brought into scientific prominence.

The experts¹ of the Medical Research Laboratory of the War Department's Air Service have pointed out that men differ greatly in their power of adjustment to changes of environment. Hence, it is found that mountain sickness befalls some individuals at a lower, others at a higher altitude; but it is al-

¹ Manual of Medical Research Laboratory, War Department, Air Service, Division of Military Aeronautics, Washington, 1918.

so certain that no one who proceeds beyond a certain elevation—the critical line for him—escapes the malady. An elevation of 10,000 feet or even less might provoke it in some; others may escape the symptoms up to 14,000 feet, while only a very few, possessed of unusual resisting power, can without much distress venture upward to 19,000 feet. The symptoms of mountain sickness, we are further reminded by the army workers, depend not only on the nature of the individual and his physical condition, but also on various intricate contingencies, especially on the amount of physical exertion made in ascending; that is, on whether the ascent is performed by climbing or by passive carriage on horse, on railway train, or in an aeroplane.

There are authentic records of balloon ascents to a height of 30,000 feet, but the effects on the balloonists were invariably distressing. Schroeder's record aeroplane ascent found its limitations in the physiologic distress resulting from an accident to the protective devices. At a height of six miles the content of oxygen in the air has been reduced from approximately 21 per cent found at sea level to 6 per cent; at a height of eight miles reached by Maeready it must be less than 5 per cent. The breathing of an atmosphere containing only 10 per cent of oxygen, equivalent to an altitude of 19,400 feet, is a venture which only a few possessed of unusual resisting power can undertake with any hope of success.

These facts attest the physiologic significance of the devices which have been perfected to supply oxygen successfully in the flights at great altitudes. In addition to the respiratory problems are the perhaps less formidable but nevertheless immediate needs of conserving body temperature in the cold environment of the higher atmosphere. In this respect, too, the difficulties have been overcome. The mastery of the upper air has involved not only the perfection of the devices for locomotion but also the successful establishment of a physiologically durable environment in the immediate vicinity of the aviator while he is being transported through the thin, cold air of far away heights.

Jour. Amer. Med. Assn. Oct. 22, 1921.

Notes on Educational Pictures

The Pathé Exchange has made a notable advance in carefully prepared films for schools and other educational institutions in their Pathé Screen Studies. The following subjects are in circulation and are accompanied by printed folders called "Teacher's Aids."

- "Athletic Movements Analyzed" (2 reels)
- "Felling Forest Giants" (1 reel)
- "Yosemite—Valley of Enchantment" (2 reels)
- "Br'er Rabbit & His Pals" (1 reel)
- "Animal Camouflage" (1 reel)
- "Birds of Prey" (1 reel)
- "Mollusks" (1 reel)

The National Non-Theatrical Motion Pictures Inc., 232 West 38 Street, New York City, with exchanges, has announced that they are circulating east of Mississippi a series of some hundreds of educational pictures. These include "Park's Popular Science Series" one reel each; "Peter's Text Film Courses" one reel each, as well as films on biology, and some of the subjects produced by the United States Department of Agriculture. They also have selected dramas and pictures on Americanization.

A 5-reel picture, "The Porcelain Lamp," made for the Cole Motor Car Co., depicting the story of gasoline engines and motors and a history of transportation can be obtained free from the National Non-theatrical Motion Pictures Incorporated.

The official agency for New York and New Jersey, The Port of New York Authority, has prepared for limited circulation an excellent four reel picture dealing with the commercial facilities, the industries, the railroads, etc., which center around New York Bay, and the river emptying into it. This subject can be had upon request from the office of the commission at 11 Broadway, New York City.

Charles F. Herm, Inc., whose office is at 220 West 42 Street, New York City, announces the scientific series of twelve subjects dealing with embryology, blood circulation, optics and hygiene. The films are either offered for sale or for limited rental in the East.

Book Reviews

Science for Beginners.—Barber, Fuller, Prior and Adams—537 pages—320 illustrations—Henry Holt & Co.

"This book is in effect a simplification for younger pupils, of the authors, First Course in General Science." While a reduction in volume from 607 to 537 pages has been made, it still has an abundance of excellent material for a solid one year course. Some rewriting has been done to simplify and to bring the matter up to date and an improvement is noted in the illustrations by the substitution of new and clearer cuts. Many users of the first book will welcome this abridged edition.

General Science.—Edgar A. Bedford—Allyn & Bacon—387 pages—296 illustrations.

Another good text. The subject matter is important and interesting. It covers well a variety of science topics over a wide field. It is not an abridged course in physical science as some of our texts

have been, but includes a fair amount of biological material. An attempt is made at using the project-problem method, but from our point of view the same mistake has been made that Van Buskirk and Smith made in labeling the *chapters "projects."* Experiments are included with the texts in appropriate places. Individual projects and references are suggested at the chapter ends.

Junior General Science—D. R. Hodgdon—340 pages—240 illustrations—Hinds, Hayden and Eldredge.

Junior General Science is an adaptation of the author's popular Elementary General Science for use of elementary pupils. The chapter headings are the same as in the former book except that the chapter on "Machines and Work" is omitted entirely in this new book. Some new material is added for example, three pages of drawings on air movements and the aeroplane. Otherwise the material in *Junior Science* seems to be the same as in *Elementary General Science*, but with portions of the text and illustrations omitted. There is not as much of the text omitted as the reduction in size (533 pages to 340 pages) indicates, because considerable of the text material is put in smaller type. The new volume has enough material for the average class in the first year of high school, especially if given with laboratory or demonstration work, and it is far better for the elementary school than the former book.

Civic Science in the Community.—Geo. W. Hunter and W. G. Whitman—432 pages—300 illustrations—American Book Company.

Civic Science in the Community is a general science text covering the science problems of the community as: Advantages of community—natural resources; weather and climatic conditions; water—relation to power, food, forests—water supply; community care of citizens—pure foods; fighting spread of disease—insects and disease—removal of wastes—street lighting—safeguarding life and property—education and recreation; Transportation on water, on land, in air—good roads—automobile—gas engines; communication; improvement of life on the earth—plants and animals—the human race.

The book is written in simple language and a style interesting to 8th and 9th grade pupils. Each chapter opens with a list of problems and projects. Essential experiments are described where needed in the text. A number of score cards if used compel pupils to study real things and conditions in his community. A carefully selected bibliography closes each chapter. The book easily lends itself to the usual formal teaching but the progressive teacher who wishes to undertake project teaching will find the project suggestions particularly helpful. The book will stimulate thought, and has a strong influence toward ethical character building and better citizenship. It can be used as a complete unit, but is better to follow "Civic Science in the Home."

Science in Junior High School—Edna W. Bailey—55 pages—in University High School Journal for October, 1921—published by University of California, Oakland, California—25 cents.

A committee of Oakland teachers have developed a three year course in general science for the 7th, 8th and 9th grades. The ninth grade plans are the only ones treated in detail in this report by Mrs. Bailey.

"The committee feels that the best justification for the course offered herewith is two-fold:

- (1) The topics chosen speak for themselves, embodying interests which are common, vital and compelling for all of us, because we are human beings living in a civilized community.
- (2) The work as tried out during the last three years has proved itself the sort of thing that Oakland children like to do and

do well. Even under many handicaps the cooperation of classes has been most encouraging and stimulating to all those who have worked with them. In a sense this outline is the work of Oakland boys and girls, quite as much as that of Oakland teachers.

The material presented is selected for its social and practical values, and yet is commonplace, so that the everyday things may stand revealed as the wonders they really are."

Besides the very full and valuable outline, suggestions for field trips, a bibliography and list of library science books complete the report. The value of score cards is indicated by two examples: One for a building lot, the other for a bakery.

The main topics in the outline are:

- A. Building a Home in Oakland.
- B. Water Supply and Sewage Disposal.
- C. Lighting.
- D. House Construction and Labor.
- E. Use of Home Grounds.
- F. Foods and Drugs.
- G. Recreation.
- H. Bacteria and Communicable Diseases.
- I. Transportation.
- J. Communication.
- K. Man's Place in the Animal Kingdom.

The Educational Value of Certain After-School Materials and Activities in Science—Morris Meister—175 pages—\$2.50—Pub. by author. Teachers College, Columbia University, N. Y. C.

This is a report of an investigation carried on through a period of years to determine what out-of-school activities are of scientific value and methods of obtaining the greatest good from such activities. The data were obtained from trial and observation with classes in the Speyer School and the Horace Mann School in New York. Much space is given to the commercial prepared sets of chemical and mechanical and electrical materials, as *chemcraft*, *structo* and *meccano*. The interesting history of these sets is given as well.

Attention is given to boy reaction to out-of-school activities and an attempt was made to measure achievement of results derived from such activities. There is a chapter devoted to discussion and conclusions and a most valuable chapter on "The Science Club and the Science Play Shop." The final chapter gives a "Summary of Important Features and Findings of the Dissertation."

Loose Leaf Laboratory Manual—Bruce Pub. Co., Milwaukee, No. 1, 35c. No. 2, 45c.

These manuals are adapted to pupil records in a variety of subjects and contain spaces with appropriate headings which help pupils to keep a neat and accurate record of experiments performed in the laboratory. No. 2 is quite similar to No. 1 but has an additional sheet one page of which is ruled for graph records. The manuals submitted have sheets for records of twenty-five experiments.

Bibliography of Tests for Use in Schools—278 titles—10 cents—World Book Company.

A Brief Treatise on Standard Tests and Measurements—W. C. Ferguson—World Books Company.

These pamphlets will be of great help to get acquainted with the latest essential school equipment—standard tests.

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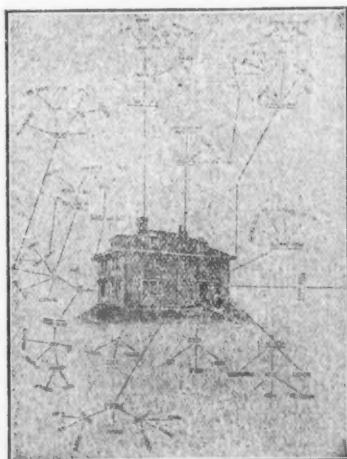
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American Forestry. Washington, D. C. Monthly. 40c a copy, \$4.00 a year. Splendid pictures for plant and tree study.

Commercial America. Phila. Com'l Museum, Phila., Pa., \$2.00 a year. Ill. Commercial production. New Inventions. Will interest Commercial geography and science teachers.

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